# INSTRUCTION MANUAL

## REGULATED POWER SUPPLIES

LMS-6000 SERIES

MP MASTER
MA28798

LAMBDA

LAMBDA ELECTRONICS MELVILLE, L. I., N. Y.

# INSTRUCTION MANUAL

# FOR

# REGULATED POWER SUPPLIES

## LMS-6000 SERIES

This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics. All information contained herein applies to all LMS-6000 series models unless otherwise specified.

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M-LMS-6000

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## SPECIFICATIONS AND FEATURES

(Specifications Apply for all models)

DC OUTPUT - Voltage and Current regulated for line and load.

TABLE I

VOLTAGE AND CURRENT RATINGS

| MODEL | VOLTAGE RANGE (volts) | MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE | | | |
|---|---|---|---|---|---|
| | | 40°C | 50°C | 60°C | 71°C |
| LMS-6008 | 0 to 8 | 20A | 20A | 16.5A | 13.5A |
| LMS-6018 | 0 to 18 | 9A | 9A | 8.2A | 6.6A |
| LMS-6040 | 0 to 40 | 4A | 4A | 3.8A | 3.1A |
| LMS-6060 | 0 to 60 | 2.8A | 2.8A | 2.6A | 2.1A |
| LMS-6120 | 0 to 120 | 1.4A | 1.4A | 1.3A | 1A |
| LMS-6300 | 0 to 300 | .56A | .56A | .52A | .40A |

Current range must be chosen to suit appropriate maximum ambient temperature.
Current ratings apply for entire voltage range.

REGULATED VOLTAGE OUTPUT

Regulation (line) ..... 0.05% of Vo(max) for input changes from 85 - 132 or 170 - 265 volts AC or 240 - 350 volts DC.

Regulation (load) ..... 0.05% of Vo(max) from 0 to full load.

Ripple and noise ..... (20 MHZ measurement bandwidth)

5 millivolts rms, 35 millivolts peak-to-peak on models LMS-6008 and LMS-6018.

10 millivolts rms, 75 millivolts peak-to-peak on models LMS-6040 and LMS-6060.

20 millivolts rms, 150 millivolts peak-to-peak on models LMS-6120 and LMS-6300.

REGULATED VOLTAGE OUTPUT ((Cont'd)

| | |
|---|---|
| Overshoot | No overshoot at turn on, turn off or power failure. |
| Negative Offset Voltage | Power supplies are shipped from the factory with minimum output calibrated to 0 +/- 10 millivolts. Internal calibration is available to achieve up to -0.1V negative offset, if desired. |
| Temperature Coefficient | 0.03% per degree C. |
| Stability (drift) | 0.1% per 8 hour period after 30 minute warm up. |
| Remote Programming: | |
| External Resistor | Adjustable from 1000 ohms per volt to 200 ohms per volt (Rp terminal to -V). LLS-6300 available only as 1000 ohms per volt. |
| Programming Voltage | One-to-one voltage change (RP terminal to -V). |
| | Zero to 5 Volt signal from RVP terminal (TB202-2) to Common terminal (TB202-6) programs output from 0 to Vo(max). (Remote programming signal must be floated from both +V and -V.) |
| Remote Sensing | Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation. |

REGULATED CURRENT OUTPUT (AUTOMATIC CROSSOVER):

| | |
|---|---|
| Regulation (line) | 0.3% Io (max) for input changes from 85 - 132 volts AC or 170 - 265 volts AC. (240-350V DC) |
| Regulation (load) | 0.3% Io(max) for output voltage changes from Vo(max) to short circuit |
| Current range | Specifications apply for 5% to full load current |
| Voltage range | As shown in Table 1. |
| Ripple | 1% Io(max) - rms. |

| | |
|---|---|
| **Remote programming** ..... | Zero to 5V signal from RCP terminal (TB202-4) to Common terminal (TB202-6) programs output from 0 to Io(max). (Remote programming signal must be floated from both +V and -V.) |

AC INPUT

| | |
|---|---|
| **Line voltage** ..... | 85 - 132 volts AC (47-440Hz) or 170 - 265 volts AC (47-440Hz) via rear panel selector switch. Where applicable, regulatory agency approval applies only for input voltages up to 250 volts AC and for input frequencies in the range of 47-63 Hz. Leakage current in the ground connection may exceed the limits allowed by the agencies at frequencies above this range. |
| Input power ..... | 245 watts max. |
| Input RMS current ..... | 4.0 Amperes max. |
| Efficiency ..... | 65% minimum |
| Input surge protection ..... | Meets IEEE 587-1980 for branch circuits and outlets (class A). |
| Inrush limiting ..... | Power-up inrush current will not exceed 40 Amps peak. |
| EMI ..... | Conducted spectrum conforms with requirements of FCC Docket 20780 Class A (85-132 VAC input) and VDE 0871 Class A (170 - 250 VAC input). |

DC INPUT - LMS-6000 Models will function with a DC input of 240 to 350 volts (Non-polarized). Input current with DC input current is 1.1 amps max. (Line select switch must be in 220 position).

PARALLEL OPERATION - LMS-6000 units of the same rated output voltage can be paralleled in a master/slave arrangement.

SERIES OPERATION - LMS-6000 units of the same rated output voltage can be connected in series with auto-tracking so that both units will track to a common reference.

## OVERLOAD PROTECTION

**Thermal** ..... Internal airflow sensing circuit shuts down unit's operation if air inlet blockage or fan rotor lockup occurs. When a thermal shutdown occurs, the main oscillator's operation will be terminated and all internal bias supplies, and the fan, will shut down. In addition, a rear panel fault indicator light will turn on. AC power must be removed for approximately 10 seconds to reset the shutdown circuit.

**Electrical**

**Input** ..... 10A/250V Normal Blo fuse F101 (in hot output line) protects AC input circuitry. 3A miniature fuse F103 and 0.25A miniature F201 protect printed circuit board from damage in the case of internal component failures.

**Output** ..... Automatic constant-current-limiting circuit limits the output current to a customer adjustable value (0% to full load), thereby providing protection for the load as well as the power supply. In addition, there is an internal inverter peak-current-limit circuit which protects the power supply during load transients.

Note: On LMS-6300 models, repeated abrupt application of 300V to short-circuit transients can cause over-dissipation and eventual damage to internal circuitry. Repetition rate of transients to short circuit should be limited to less than 2 per minute for long-term operation. (Note that once in short-circuit, continuous operation is per normal rating limits)

## OVERVOLTAGE PROTECTION

All LMS-6000 models include a built-in adjustable overvoltage protection circuit which prevents damage to the load caused by excessive power supply output voltage. Exceeding the overvoltage set point will shut down the unit's operation and cause the rear panel fault indicator to light. AC power must be removed from the unit for approximately 10 seconds to reset the OV shutdown circuit.

OVERVOLTAGE PROTECTION (Cont'd)

| | |
|---|---|
| Overvoltage Adjustability Range ..... | Model LMS-6008: 4 to 11 VDC<br>Model LMS-6018: 4 to 24 VDC.<br>Model LMS-6040: 8 to 50 VDC.<br>Model LMS-6060: 8 to 70 VDC.<br>Model LMS-6120: 20 to 130 VDC.<br>Model LMS-6300: 55 to 330 VDC. |

REMOTE TURN-ON / TURN-OFF - A TTL low signal (0 to 0.5V), or a short, between Remote on/off terminal (TB202-5) and common terminal (TB202-6) enables the output. A TTL high (2.8 to 5V), or open circuit, between the Remote on/off terminal and the common terminal will bring the output voltage to zero.

COOLING - Forced-air cooling using ball-bearing, long-life fan (no lubrication needed). Fan draws air in through front portion of chassis and exhausts air through perforations at rear of unit. Leave adequate clearance at all air intake and exhaust openings.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE - Continuous duty from 0 to 71°C ambient with corresponding load current ratings for all modes of operation, and appropriate derating.

STORAGE TEMPERATURE (Non-operating) - -55°C to +85°C

INPUT/OUTPUT CONNECTIONS

| | |
|---|---|
| AC input and line safety ground ..... | IEC power line connector (recessed 3-pin male). Line cord should be chosen to be compatible with maximum expected ambient temperature of application. |
| DC output ..... | Heavy-duty, printed-circuit-board-mounted terminal block at rear of chassis (TB201). |
| Output ground ..... | Tapped hole in chassis at rear of unit. |
| DC sensing, Remote voltage programming, Remote current programming, Remote on/off, Remote resistance programming, Parallel operation ..... | Rear panel, printed-circuit-board mounted, lugless connector (TB 202 - 13 positions). |

CONTROLS

| | |
|---|---|
| DC output ..... | Separate multi-turn, screwdriver-adjust potentiometers for constant-voltage and constant-current set points. (Located at top of unit, directly above rear panel output terminals.) |

CONTROLS (Cont'd)

| | |
|---|---|
| Overvoltage control | Multi-turn, screwdriver-adjust potentiometer located at top of unit in middle of chassis. |

MOUNTING - One mounting surface. Mounting position not restricted.

PHYSICAL DATA

| | |
|---|---|
| Size | 4-9/32" x 3-13/16" x 10 3/4" |
| Weight | 7 lbs., 4 oz net; 8 lbs shipping |
| Finish | Gray, FED. STD. 595, No. 26081 |

ISOLATION RATINGS

| | |
|---|---|
| Input to output | 3000 Volts rms |
| Output to ground | 500 Volts rms - LMS-6008 to LMS-6040;<br>1000 Volts rms LMS-6060 and LMS-6120;<br>1600 Volts rms on LMS-6300 |
| Input to ground | 1500 Volts rms. |

WARRANTY - 3 years, parts and labor.

ACCESSORIES

| | |
|---|---|
| Rack Adapter system | LRA-15, -17, -18. |

Cable System.

Lambda MATE or GPIB systems.

## OPERATING INSTRUCTIONS

### CONTROLS, FUSES AND INDICATORS

Output Voltage Control R280. This is a multi-turn, screwdriver-adjust potentiometer located at the top of the chassis toward the rear of the unit. Clockwise rotation of this control will vary the constant voltage operating point from zero (fully CCW) to approximately 105% of rated output voltage (fully CW).

Output Current Limiter Control R282. This is a multi-turn, screwdriver-adjust potentiometer located at the top of the chassis toward the rear of the unit. Clockwise rotation of this control will vary the constant-current limiting point from zero (fully CCW) to approximately 105% of the 40°C current rating (fully CW).

Overvoltage Control R226. This is a multi-turn, screwdriver-adjust potentiometer located on the top of the chassis toward the middle of the unit. Clockwise rotation of this control will vary the overvoltage limit-point from the minimum specified value (fully CCW) to the maximum specified value (fully CW).

Fuse F101. This is a 10A/250V Normal-Blo fuse located in series with the hot AC line. This fuse protects the power supply from excessive overcurrents in the event of an internal component failure. NOTE: POWER SHOULD BE REMOVED FROM THE UNIT BEFORE ANY CHECKING OR REPLACEMENT OF FUSE IS ATTEMPTED.

Fuse F103. This is a 3A/250V normal-blo miniature fuse located in series with the main inverter current path. This fuse protects printed circuit board traces in this circuit in the event of an internal component failure. NOTE: POWER SHOULD BE REMOVED FROM THE UNIT BEFORE ANY CHECKING OR REPLACEMENT OF THIS FUSE IS ATTEMPTED.

Fuse F201. This is a .25A/125V normal-blo miniature fuse located in series with Pin 6 of TB202 (common) to protect against misconnection of load.

Line Select Switch S101. This is a screwdriver actuated switch which is accessible through a hole in the rear of the unit. Selection of input voltage range (85-132 or 170-265 VAC/240-350 VDC) should only be performed with AC power removed from unit.

Fault Indicator. Located on the rear of the unit, the fault indicator will illuminate if either an overvoltage or airflow interruption shutdown occurs.

### CONNECTIONS

AC Input. AC input connection should be made using an IEC type, three-prong female connector.

DC Output. Load connections must be made to two-position terminal block TB201. This block is designed to handle the maximum current and voltage attainable from the supply and will accept a No. 8 Ring-or Spade-type lug.

Sensing. Terminals for sensing output voltage are located on TB202, and are terminals 10 and 12. Local sensing can be achieved by strapping terminal 10 to terminal 11 (connects to +V) and terminal 12 to terminal 13 (connects to -V). See figure 3.

CONNECTIONS (Cont'd)

Remote Voltage Programming, Remote Current Programming, Remote On/Off, Remote Resistance Programming, Parallel Operation. Terminals for achieving these functions are located on TB202, pins 1 through 9. See Modes of operation and Operating procedures for details. TB202 is a lugless-type connector which will accept up to an AWG No. 20 stripped wire.

Load Ground Connection. This power supply can be operated with either the positive or negative terminal grounded, or with neither terminal grounded. A tapped hole in the chassis at the rear of the unit is provided for grounding one of the output terminals, if desired.

> NOTE: When operating the supply with neither output terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

BASIC MODES OF OPERATION AND OPERATING PROCEDURES

This power supply is designed to operate as a constant-voltage source or as a constant-current source. Automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant-voltage source while the load current is less than the current value $I_{LIM}$ as set by the current-limit control R282, or, where applicable, by the external current programming signal applied to the RCP terminal. When the load current $I_L$ ($=Vo/R_L$) reaches $I_{LIM}$, the supply will crossover automatically and will operate as a constant current source. Further decrease in the value of the load resistor will result in a decrease of voltage across the load while the current remains regulated to $I_{LIM}$.

Constant Current. The power supply will function as a constant-current source while the load voltage $V_L$ does not exceed the voltage value set by the Output Voltage control 280, or where applicable, by the external programming signal applied to either the RVP terminal or the Rp terminal. When the load resistance is high enough so that the load voltage Vo ($=I_L \times R_L$) reaches the value set by the programming controls, the supply will automatically crossover and operate as a constant voltage source.

OPERATION AS A CONSTANT-VOLTAGE SOURCE

The output impedance and regulation of the power supply at the load may change when using the supply as a constant-voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on these characteristics, remote sensing can be used. Recommended types of supply-load connections, with local or remote sensing, are described in the following paragraphs.

Local Sensing Connection, Figure 3. Local sensing is the connection suitable for applications with relatively constant load where extremely close load regulation over the full rated current excursion is not required at the load.

Remote Sensing Connection, Figure 4. Remote sensing provides complete compensation for the DC voltage drop in the connecting cables. Sensing leads should be a twisted pair to minimize AC pickup. A 2.5UF capacitor may be required between the output terminals and sense terminals to reduce noise pick-up.

## SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

Constant-Voltage Operation, Internal Programming, Adjustable Current Limit.

When shipped from the factory, the supply is ready for use as a constant-voltage/constant-current source with automatic crossover. Operating points for constant current and constant voltage are preset for maximum rated values. Jumpers are in place for local voltage sensing, figure 3. If remote-sensing connection is desired, the load should be wired as shown in figure 4.

Determine load requirements and select wire size from figures 1 and 2.

After applying input power, output voltage can be adjusted to any desired value via output voltage control R280. The current-limit point can be adjusted by using one of two methods. In the first method, connect a current-measuring device (Ammeter or shunt and voltmeter), rated to handle the maximum rated current from the supply, across the output terminals and then adjust constant-current control R282 to achieve the desired limit point. The second method involves measuring the voltage between RCP terminal (TB202-4) and common terminal TB202-6). The current-limit set-point will be directly proportional to the voltage between these terminals, with zero volts corresponding to zero output current and 5 volts corresponding to full-rated output current at 40°C.

Programmed Constant-Voltage Operation Using a Zero to 5-Volt External Source. The power supply output voltage can be programmed via an external zero to 5 volt source by utilizing the RVP terminal on TB202. The jumper between terminals TB202-1 and -2 should be removed and the external source connected between terminals TB202-2 and -6 (figure 5). Please note that the common terminal is at approximately the same potential as the +V terminal. The constant-voltage operating point will be directly proportional to the external voltage, with zero output voltage corresponding to zero programming and rated output voltage corresponding to 5 volts programming. Remote versus local sensing and current limit set point adjustment are explained in the preceding text.

Programmed Constant-Voltage Operation Using An External Resistor. The power supply output voltage can be programmed via an external resistor by utilizing the Rp terminal on TB202. The external resistor should be connected between TB202 terminal 9 and -V, while the -S terminal (TB202 terminal 12) is not connected (figure 6).

On LMS-6008 through LMS-6120 models, the value of external resistor can be chosen to be either 200 ohms per volt (nominal) or 1000 ohms per volt (nominal) by presetting the voltage from RVP terminal TB202-2 to common terminal TB202-6 via output-voltage-adjust control R280. A 5-volt potential between these terminals corresponds to 200 ohms per volt (nominal) while a 1-volt potential between these terminals corresponds to 1000 ohms per volt (nominal). The unit is factory-calibrated for 200-ohms per-volt (nominal) operation.

LMS-6300 models require a 1000-ohms per-volt external programming resistor. Output-voltage-adjust control R280 should be set to deliver 5 volts between TB202-2 and TB202-6.

In order to protect any external shorting contact made between Rp and -V from seeing excessive current during a programming-down execution, an internal resistor is connected in series with the Rp terminal that limits the maximum peak current out of the Rp terminal to 1 Amp. This resistor will cause a small offset voltage to be present at the output terminals. This offset voltage will range from approximately +0.05 volts on model LMS-6008, set at 200 ohms

per volt, to +0.5 volts on model LMS-6120, set at 200 ohms per volt. The magnitude of this offset voltage can be limited by increasing the ohms-per-volt utilized in the application. For example, on model LMS-6008, the offset becomes approximately +0.01 V, set at 1000 ohms per volt, and on model LMS-6300 it becomes approximately +0.27V, set at 1000 ohms per volt. Remote versus local sensing and current limit set point adjustment are as described above under Constant-Voltage operating procedures.

Programmed Constant Voltage Operation Using a One-To-One External Voltage Source Referenced to -V. The power supply output voltage can be programmed via an external one-to-one voltage by utilizing the Rp terminal on TB202. The external voltage source should be connected between Rp terminal (TB202-9) and -V, while leaving -S terminal (TB202-12) disconnected (figure 7). In addition, terminals 7 and 8 should be open circuited.

The external source should be current limited to no more than 20mA in order to protect internal components in the LMS units.

In order to limit peak currents in the Rp terminal to approximately one amp during programming up and programming down transients, an internal resistor is included in series with the Rp terminal. Remote versus local-sensing and current-limit-set-point adjustment are as described above under Constant Voltage operating procedures.

## OPERATION AS A CONSTANT-CURRENT SOURCE

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the output voltage control (R280) setting, the power supply crossover circuit will cause the unit to operate as a constant-voltage supply.

## SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT, OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

Constant-Current Operation, Internal Programming, Adjustable Voltage Limit. When shipped from the factory, the supply is ready for use as a constant-voltage/constant-current source with automatic crossover. Operating points for constant current and constant voltage are preset for maximum rated values.

Determine load requirements and select wire size from figures 1 and 2.

After applying power, output current can be adjusted to any desired value via output current limit control R282. The maximum voltage-limit point can be set via one of two methods. In the first method, remove the load and then adjust output-voltage control R280 to the desired voltage limit. The second method involves measuring the voltage between RVP terminal TB202-2 and common terminal TB202-6. The voltage-limit set-point will be directly proportional to the voltage between these two terminals, with zero volts corresponding to zero output volts and 5 volts corresponding to full-rated output voltage, and can be adjusted by varying R280.

Programmed Constant-Current Operation Using a Zero-to-5-Volt External Source. The power supply output current-limit can be programmed via an external zero-to-5 volt source by utilizing the RCP terminal on TB202. The jumper between terminals TB202-3 and -4 should be

removed and the external source should be connected between terminals TB202-4 and -6 (figure 8). It should be noted that the common terminal is at approximately the same potential as the +V terminal. The constant-current operating point will be directly proportional to the external voltage, with zero output corresponding to zero programming and full-rated output-current at 40°C corresponding to 5 volts programming. Maximum voltage-limit set-point is as described above.

## OTHER MODES OF OPERATION

TTL Compatible Remote Turn-On/Turn-Off. A TTL compatible remote turn-on/turn-off function is available by utilizing terminal 5 of TB202. A TTL low signal (0 to 0.5 Volts) or a short between terminal 5 and terminal 6 of TB202 enables the output voltage. A TTL high (2.8 to 5 Volts), or open circuit between terminal 5 and terminal 6 of TB202 will cause the output voltage to go to zero, see figure 9. It should be noted that terminal 6 (common) is at aproximately the same voltage potential as +V, thus any TTL signal must be floated on top of +V.

Parallel Operation. The output current capability of LMS-6000 power supplies can be increased by connecting supplies of the same output voltage rating in parallel. The supplies can be operated in a MASTER/SLAVE configuration by using the circuit shown in figure 10. The jumper between terminals 7 and 8 of TB202 on the SLAVE unit must be removed, and a connection must be added from terminal TB202-6 of the MASTER unit to terminal TB202-9 of the SLAVE unit. In addition, a jumper should be added between TB202 terminals 6 and 10 of the SLAVE unit. In addition, a jumper should be added between TB202 terminals 6 and 10 of the SLAVE unit. Note that constant-current specifications do not apply in parallel operation.

Series Operation. The voltage capability of LMS-6000 power supplies can be extended by series operation of two power supplies of equal voltage ratings. A maximum of 500 volts can be connected between either the +V or -V terminal and chassis ground. Figure 11 shows the connection for this series operation.

Diodes $CR_A$ and $CR_B$, which protect the units from carrying excessive current in the event of one unit not being powered up (i.e. fan not operational), must be capable of withstanding the maximum rated-current.

For master/slave operation with auto tracking, TB202 terminals 7 and 8 of the slave unit are disconnected from one another. Also, an external resistor, Rx, is connected from terminal TB202-10 of the master unit to terminal TB202-9 of the slave unit. The value of Rx is 1600 Ω for model LMS-6008, 3600 Ω for model LMS-6018, 8000 Ω for model LMS-6040, 12,000 Ω for model LMS-6060, 24,000 Ω for model LMS-6120 and 300,000 Ω for model LMS-6300. Due to the existence of certain tolerances, the value of Rx required for perfect tracking may vary slightly from the nominal values given here. In addition, Rx must be able to dissipate up to 0.04 watts on model LMS-6008, 0.09 watts on model LMS-6018, 0.2 watts on model LMS-6040, 0.3 watts on model LMS-6060, 0.6 watts on model LMS-6120 and 0.3 watts on LMS-6300.

Utilization of Remote Features and Implications on Output Noise. When various remote features of the power supply are utilized (such as remote voltage programming, remote current programming, remote TTL compatible on/off or remote resistance programming), or when power supplies are utilized in parallel or series combinations, output ripple and noise may be slightly degraded due to high-frequency spikes caused by noise radiated thru wires connected to terminals 1 through 9. Normally, the amplitude and spectral content of these spikes is such that a small decoupling capacitor connected at the remote load-distribution point will adequately

attenaute any noise pickup. However, in extremely sensitive applications, where spikes cannot be tolerated, radiated noise emanating from wires connected to terminals 1 through 9 can be minimized by utilizing high-frequency-rated ferrite noise suppressors on each of the externally connected signal wires. In order to be effective, these noise suppressors must be physically located on the signal wire at a point no further than 3 inches from where the wire connects to the power supply terminal. These noise suppressors can either be obtained from your local Lambda sales office or by contacting the factory. Figures 15 and 16 detail the use of these noise suppressors.

These suppressors are built into the unit for the +S and -S terminals and no external suppressors are required to minimize noise radiation while using remote sensing.

## ADJUSTMENT OF OVERVOLTAGE CONTROL R226

The overvoltage protection circuit provides an adjustable means of shutting down the power supply if the output voltage exceeds a pre-determined safe value. In the event of an overvoltage shutdown, the main power oscillator is disabled along with all output bias supplies and the fan supply. A rear panel indicator light will turn on to indicate a fault condition. Once the cause of the overvoltage has been determined and removed, the shutdown circuit can be reset by removing AC power to the unit for approximately 10 seconds.

The procedure for setting the overvoltage control is as follows:

(The power supply should be removed from associated equipment, be at an ambient temperature of 25-30°C and operated at nominal line voltage.)

1. The recommended voltage protection point is 115% of the selected power supply operating voltage or 1.5 volts above the selected operating voltage, whichever is greater. (If set too low, load-off transients may cause the overvoltage detection circuit to trip.)

2. Turn the OV adjust control R226 fully clockwise.

3. Apply AC power to the unit and adjust the output voltage to the desired protection point. If the power supply does not have adequate output range to reach this point omit steps 4 and 5, and proceed to step 6.

4. Slowly rotate the OV adjust control CCW while monitoring the output voltage. When the output voltage drops sharply and the rear panel fault indicator light comes on, the OV shutdown point has been reached.

5. The voltage protection point is now set. Remove power from the unit for approximately 10 seconds to reset the shutdown circuit. Reduce the output voltage setting before reapplying power to the unit.

6. If the power supply adjustment range is not adequate to reach the desired OV protection point, proceed as follows:

   (a) Adjust the power supply output to the normal operating voltage.

   (b) Slowly turn the OV adjust control R226 CCW until the output voltage sharply drops and the rear panel fault light comes on.

(c) Refer to the chart below, select the appropriate volts/turn ratio and turn the OV adjust control clockwise by the number of turns equivalent to 115% of the operating voltage (or 1.5 volts, whichever is greater) to bring the OV set-point to the proper value.

| MODEL | NOMINAL VOLTS PER TURN (R226) |
|---|---|
| LMS-6008 | 0.6 |
| LMS-6018 | 1.7 |
| LMS-6040 | 3.5 |
| LMS-6060 | 5.2 |
| LMS-6120 | 9.2 |
| LMS-6300 | 22.5 |

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermal Shutdown. The thermal shutdown circuit will activate if any interruption to normal cooling airflow occurs (such as a blocked air inlet or fan rotor lockup). When a thermal shutdown occurs, the main oscillator circuit will be inhibited, thereby bringing the supply output to zero, and causing the rear panel fault-indicator to light. In order to reset the unit after a thermal shutdown, first determine and remove the cause(s) of airflow interruption, and then remove power from the unit for at least 10 seconds, if the unit has already cooled down. (If the unit is not cooled down, remove power for up to 2 minutes immediately subsequent to a thermal-shutdown occurrence).

Fuse Shutdown. Fuses will blow when the maximum rated current value for the fuses are exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse-protected circuit operative.

NOTE: Power should be removed from the unit before checking or replacing any fuse.

Overvoltage Shutdown. When the power supply output increases above the overvoltage limit, the overvoltage protection circuit will shut down the main oscillator's operation, thereby causing the output voltage to go to zero. During overvoltage shutdown, the rear panel fault indicator lamp will be lit. After eliminating the cause(s) for overvoltage, resume operation of the power supply by interrupting the AC input circuit for a period of at least 10 seconds. (refer to TROUBLESHOOTING CHART).

## MAINTENANCE

### GENERAL

This section describes trouble analysis routines, replacement procedures and calibration and test procedures that are useful for servicing this Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on SPECIFICATIONS AND FEATURES for minimum performance standards.

### PERIODIC MAINTENANCE

The unit should be disconnected from associated equipment and inspected for dust accumulation due to forced-air cooling. Inspect every six months or more often if operated in extremely dusty environments. To inspect the interior of the unit, first disconnect AC input power to the unit and then remove the top cover by removing the six screws securing the cover. If the unit shows any dust accumulation, it should be vacuumed clean in order to assure proper heat-sink efficiency.

### TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before troubleshooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumper and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 14, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short cicuits and damaging circuit components.

### CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an instrument that has a highly limited current capability. Observe proper polarity for PNP or NPN transistors to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance.

For good transistors, the forward resistance for any junction is <u>always</u> greater than zero.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, wherever possible, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

> <u>NOTE:</u> The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

## PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder, it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to the measuring instrument.

3. Whenever possible, use a heat sink when soldering transistors.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain, or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board, never pry or force loose the part; unsolder the component by using the wicking process described below:

(a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or No. 16 stranded wire with 1/2 inch insulation removed.

(b) Dip the wick in liquid rosin flux.

(c) Place the wick onto the soldered connection and apply soldering iron onto the wick.

(d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

NOTE: When dealing with surface-mount technology parts, devices with two leads can be removed with a pair of tweezers and a soldering iron first by heating both ends of the device until the solder is melted and then by quickly removing the part with the tweezers. Replacement first requires pre-wetting the mounting pads with a small amount of solder and then holding the new part in place with the tweezers. First one end of the part is heated and then the other end is heated to the point where the solder melts and flows onto the part, thereby forming new solder joints. Care should be exercised to avoid damaging the part(s) because of accidental overheating or mechanical stress.

Removel or repair of SMT devices, which have more than two leads is best left to SMT repair stations specifically designed to handle removal and installation of these parts using special tools and techniques.

## TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.

(b) Power supply is connected for constant voltage with local sensing.

## SAFETY NOTICE

DANGEROUS VOLTAGES, DUE TO CHARGED CAPACITORS, MAY EXIST IN THIS EQUIPMENT EVEN IF AC POWER IS REMOVED. OBSERVE NORMAL SAFETY PRECAUTIONS WHEN SERVICING.

## TROUBLESHOOTING CHART

| Symptom | Probable Cause | Remedy |
|---|---|---|
| 1. Zero volts DC output (with output voltage and current limit controls for maximum). | Short circuit across output of supply. | Check load connections. Correct as necessary. |
| | F101, F103, F201 open. | Replace fuses as required. If fuses blow immediately, see additional symptoms below. |
| Additional symptoms | | |
| A. OV/OT fault indicator light on. | Overvoltage fault | See manual section on procedure for setting OV adjust. |
| | Overtemperature fault | Check for locked rotor on fan. Check for air inlet blockage. |
| B. Fan operational. 5 volts measured from RVP to common and from RCP to common. Zero or negative voltage from IC208 pin 7 to common. | IC204, IC205 or IC208 defective. | Check and replace as necessary. |
| C. Fan operational. 5V measured from RVP and RCP to common. Greater than 5V from IC208 pin 7 to common. | IC206, Q202 defective. | Check and replace as necessary. |
| | CR116, CR117 open. C103 shorted. | Check and replace as necessary. |
| D. Fan operational. RVP or RCP to common do not measure 5V. | IC219 or IC210 defective | Check and replace as necessary. |
| | Open circuit at remote on/off terminal TB202-5. | Check output wiring. Correct as necessary. |
| | IC211 or IC215 defective. | Check and replace as necessary. |

TROUBLESHOOTING CHART (Cont'd)

| Symptom | Probable Cause | Remedy |
|---|---|---|
| Zero output continued: | | |
| E. RVP to common or RCP to common do not measure 5V. Fan not operational. Output of bias regulators IC201 and IC202 not +/-12V (respectively). Inputs ok. | IC201, IC202 defective. | Check and replace as necessary. |
| F. Same as above, except inputs of IC201/202 not correct. | Oscillator circuit not operational. | See below. |
| | CR114, CR115, CR118, CR119 defective. | Check and replace as necessary. |
| G. Fan not operational F101, F103 not blown. No oscillator waveform at Q102. | IC101 defective, Q103 shorted, CR113 shorted. | Check and replace as necessary. |
| H. F101 blown, F103 ok. | CR101, C105, C107 shorted. | Check and replace as necessary. |
| I. F101, F103 blown. | Q101, Q102 shorted. | Check and replace as necessary. |
| 2. High output voltage, no control of output. | Open sense lead. | Refer to appropriate connection diagram and correct as required. |
| 3. Unit cannot be adjusted to attain rated $V_o$ or $I_o$ or minimum output. | Unit out of calibration. | Refer to CALIBRATION PROCEDURES in manual and recalibrate unit in the proper sequence. |
| 4. Unit can not be adjusted to zero volts. | IC207, IC212, IC213, Q201, Q205 defective. | Check and replace as necessary. |

PERFORMANCE CHECKS

Checks With Constant Voltage Operation. Check the ripple and regulation of the power supply using the test connection diagram shown in figure 12. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Load regulation can be checked by varying the load from no-load to full-load while monitoring the output voltage. Line regulation can be measured by varying the input with a variac between low line and high line while observing the output voltage. Good technical judgement should be observed in the routing and layout of test leads to minimzie AC pickup.

Output ripple should be measured directly at the power output terminals of the power supply. A 20 MHz bandwidth oscilloscope should be used. In order to minimize pickup from close proximity radiated fields, the length of the ground wire on the scope probe should be minimal. A true RMS voltmeter similar to a FLUKE 8920A should be used to measure RMS output ripple.

Checks With Constant Current Operation. Check the regulation of the power supply using the test connection diagram shown in figure 13. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Load regulation can be checked by switching from a short circuit to a maximum output voltage condition while monitoring the output current via the current-measuring shunt. Line regulation can be measured by varying the input line with a variac while monitoring the output current via a current-measuring shunt. In order to measure the relatively small regulation signal, a shunt of sufficiently large voltage drop should be used.

Constant current RMS ripple should be measured by connecting a true RMS voltmeter across the current measuring shunt. A low-pass filter comprised of a resistor and capacitor may be required to filter out high frequency noise spikes due to shunt inductance and pickup.

## POWER SUPPLY CALIBRATION PROCEDURE

The following is a list of calibration controls located within the LMS-6000 power supply:

| | |
|---|---|
| R202 | Vo(min) adjust |
| R223 | Vo(max) adjust |
| R204 | Io(min) adjust |
| R264 | Io(max) adjust |

Calibration of R202 must always be performed together with that of R223. Calibration of R204 must always be performed together with that of R264.

Before performing any calibrations, the power supply must be removed from associated equipment and must be at an ambient of 25 to 30°C. Unit must be wired in local sense with internal programming, figure 3, and must be operating from a nominal AC line.

Calibration of Output-Voltage-Range Controls R202 and R223.

1. With no load on the output of the power supply, adjust the output voltage control R280 fully CCW.

2. While monitoring the output voltage, adjust R202 so that $V_o$ is between -.01 and +.0 volts.

> NOTE: In certain applications it may be desirable to have the minimum output less than zero volts. This can be achieved by adjusting R202 CCW until the minimum output goes down to the desired value, with a -0.1V absolute minimum.

3. Monitor the voltage between terminal 2 and terminal 6 of TB202. Turn output voltage control R280 CW until the monitored voltage between these terminals is between 4.95 and 5.05 volts.

4. Adjust R223 until the output voltage monitored from +V to -V indicates the rated output voltage of the supply +/-.01 volts.

5. Seal R202 and R223 with RTV sealant.

Calibration of Output-Current-Range Controls R204 and R264.

1. With no load on the output of the power supply, adjust output current limit control R282 fully CCW.

2. Apply a short-circuit through a measurement shunt connected across the output of the supply, figure 13.

3. Adjust R204 until the measured output current is between -0.01 and +0.01 amps.

4. Monitor the voltage between terminal 4 and terminal 6 of TB202. Turn the output current-limit control R282 CW until the monitored voltage is between 4.95 and 5.05 volts.

5. Adjust R264 until the monitored output current is the rated 40°C current of the supply +/-.01 amps.

6. Seal R204 and R264 with RTV sealant.

## SERVICE

When additional instructions are required or repair service is desired, contact the nearest Lambda office where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

## PARTS ORDERING

Standard components and special components in the Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function and location of the part.

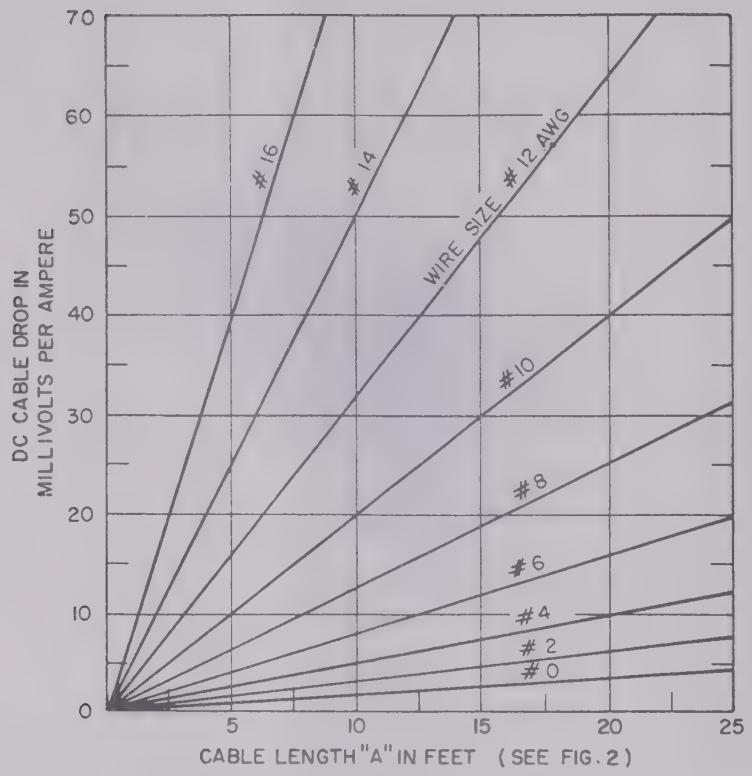



Figure 1. Cable Connection Chart

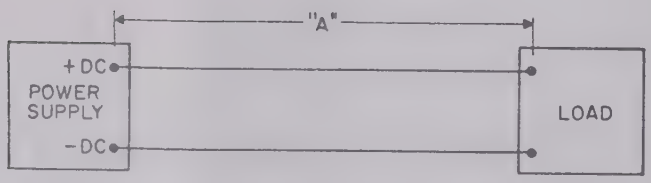
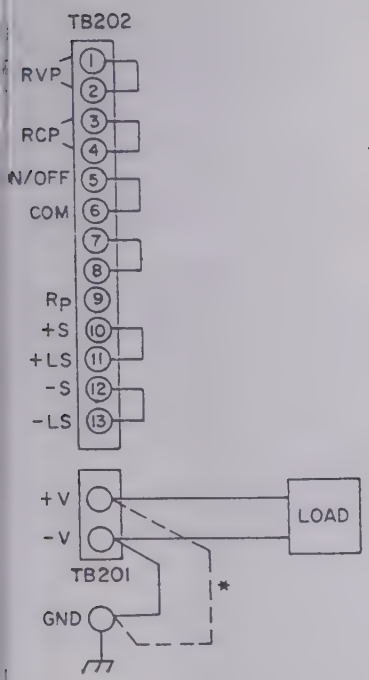
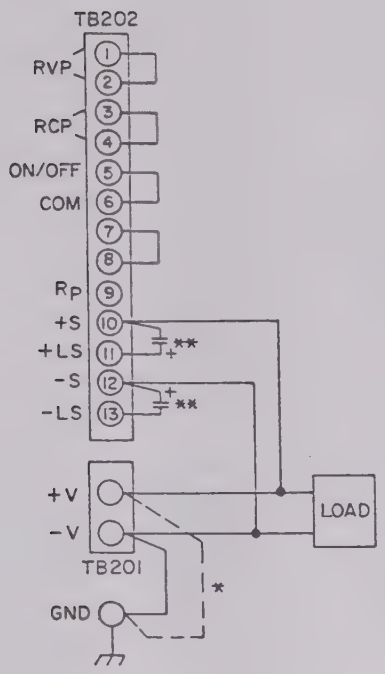



Figure 2. Cable Length "A" in Feet.



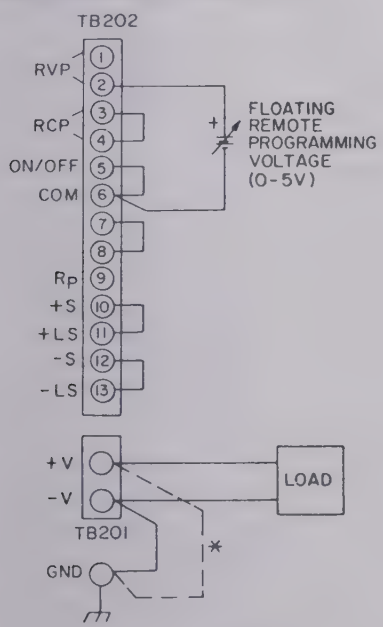

NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.

Figure 3. Local Sensing Connection.

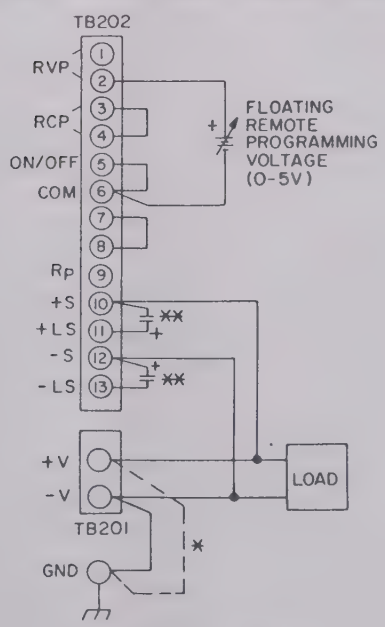



NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.
** A 2.5MF, ELECTROLYTIC CAP. MAYBE REQUIRED.

Figure 4. Remote Sensing Connection.



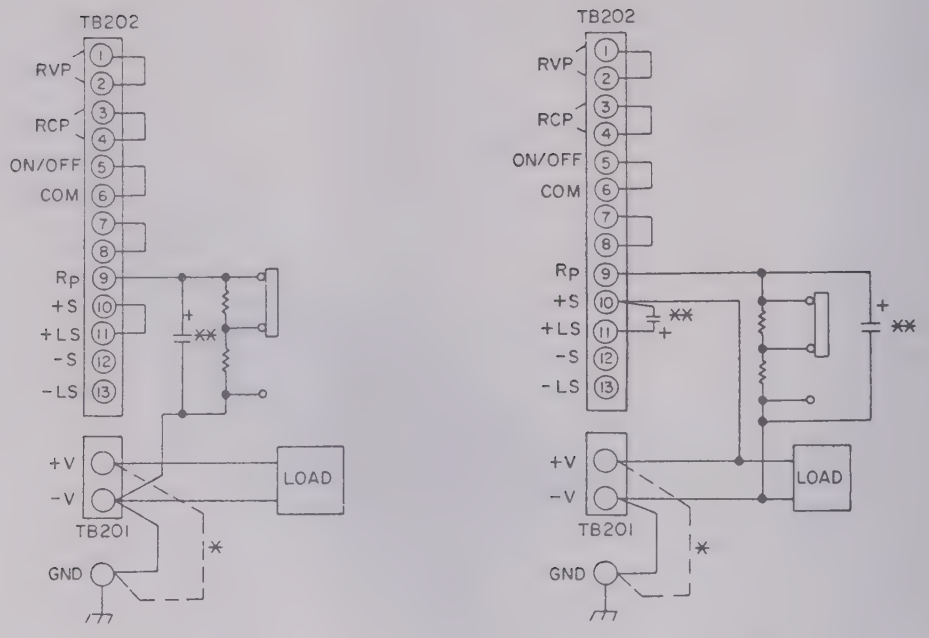

(A) LOCAL SENSING




(B) REMOTE SENSING

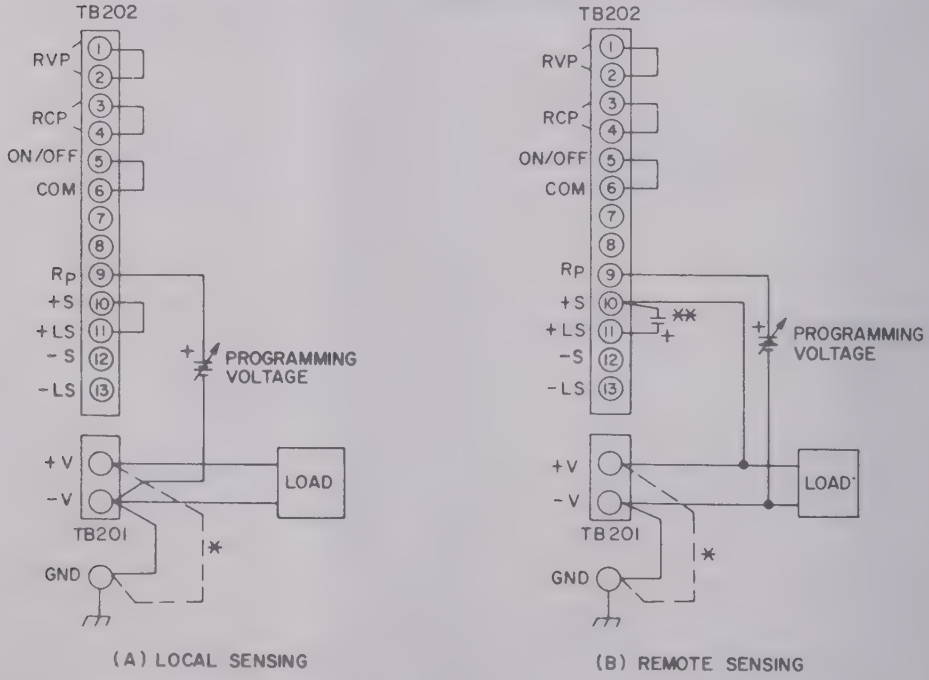
NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.
** A 2.5MF ELECTROLYTIC CAP. MAY BE REQUIRED.

Figure 5. Programmed Constant Voltage Using a Zero to 5V External Source



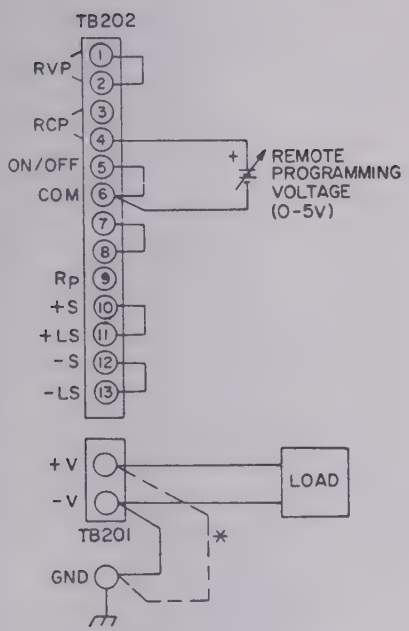

NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.
** A 2.5UF ELECTROLYTIC CAP. MAY BE REQUIRED.

Figure 6. Programmed Voltage Using an External Resistor.



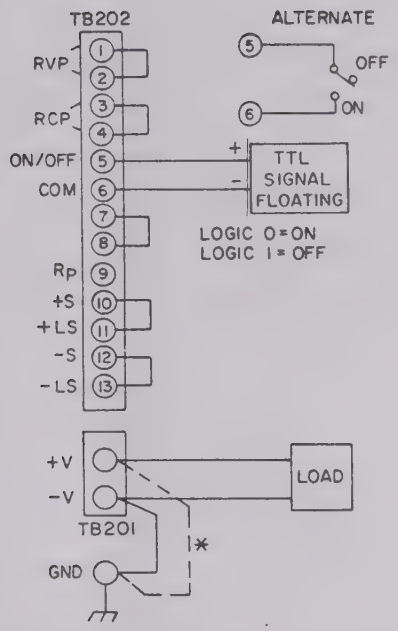

NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.
** A 2.5MF, ELECTROLYTIC CAP. MAY BE REQUIRED.

Figure 7. Programmed Voltage Using an External Voltage Source Referenced to -V.



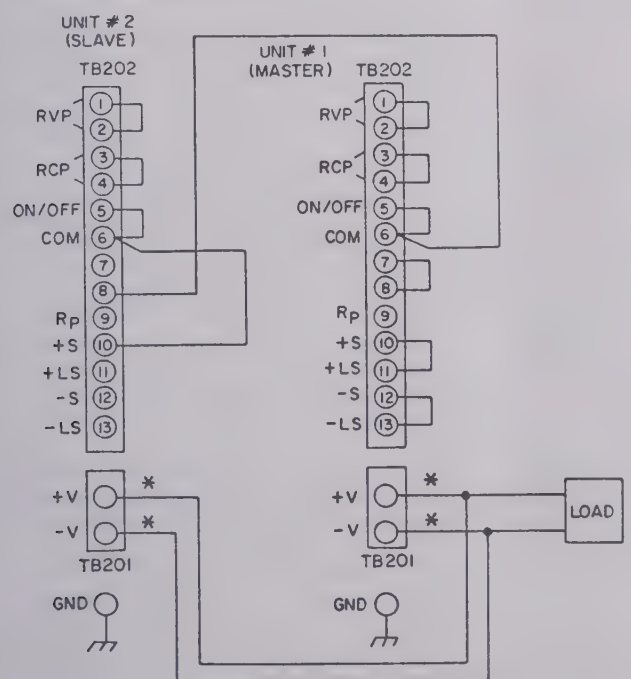

NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.

Figure 8. Programmed Constant Current with a Zero to 5V External Source.



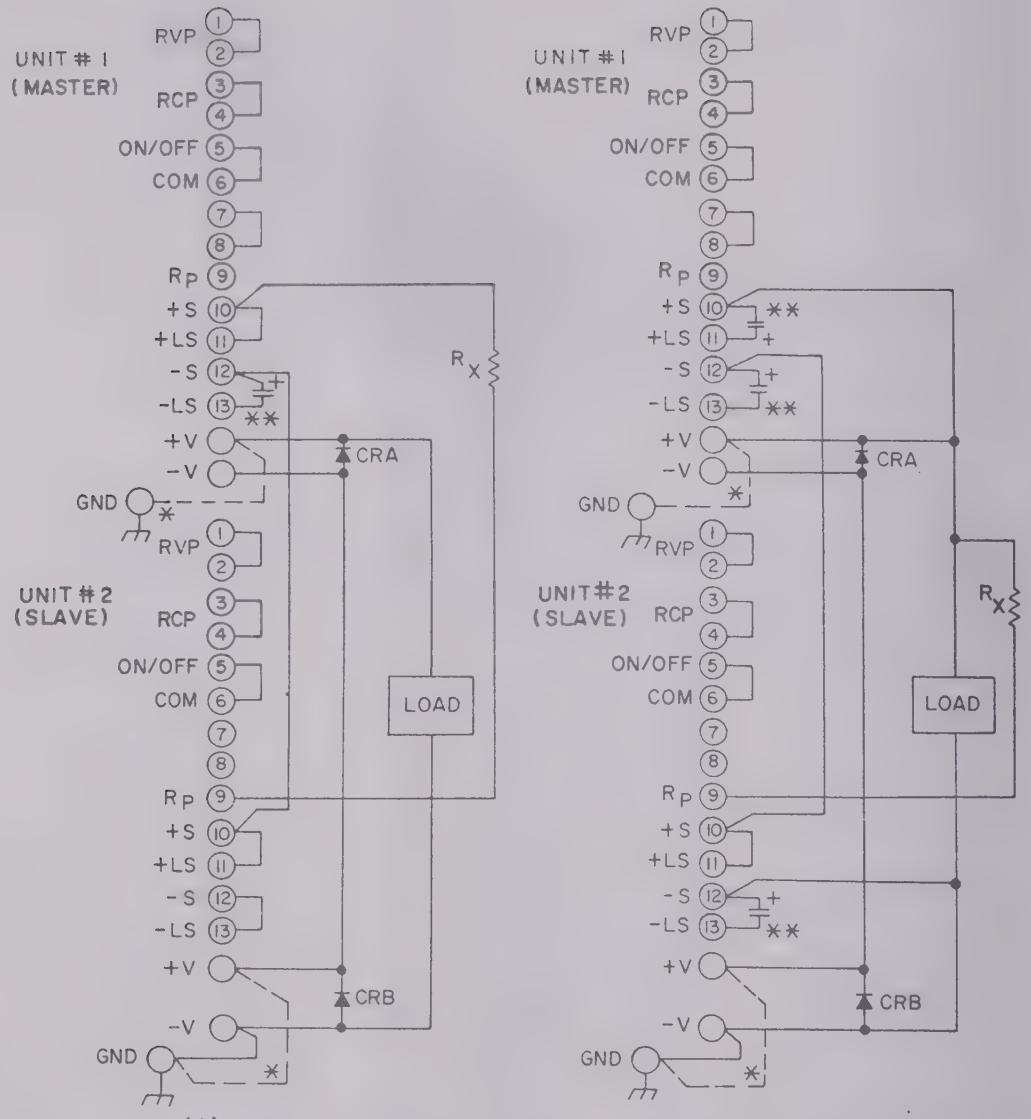

NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.

Figure 9. TTL Compatible Remote On/Off




NOTE: * VOLTAGE DROP ON THESE WIRES SHOULD BE BALANCED TO PROVIDE FOR PROPER CURRENT SHARING.

Figure 10. Parallel Operation.




NOTE: * MAKE ONLY ONE GROUND CONNECTION FOR SERIES COMBINATION. TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM -V TO GND AND RECONNECT AS DESIRED.
** A 2.5UF ELECTROLYTIC CAP. MAY BE REQUIRED.

Figure 11. Series Connection.

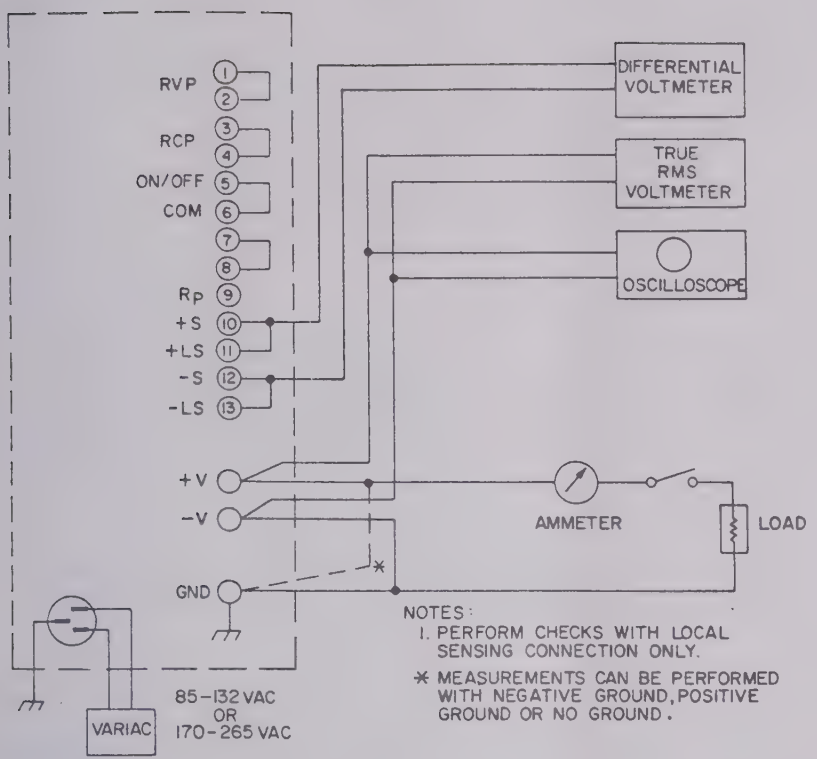



**Figure 12. Test Connections for Constant Voltage Performance Checks.**

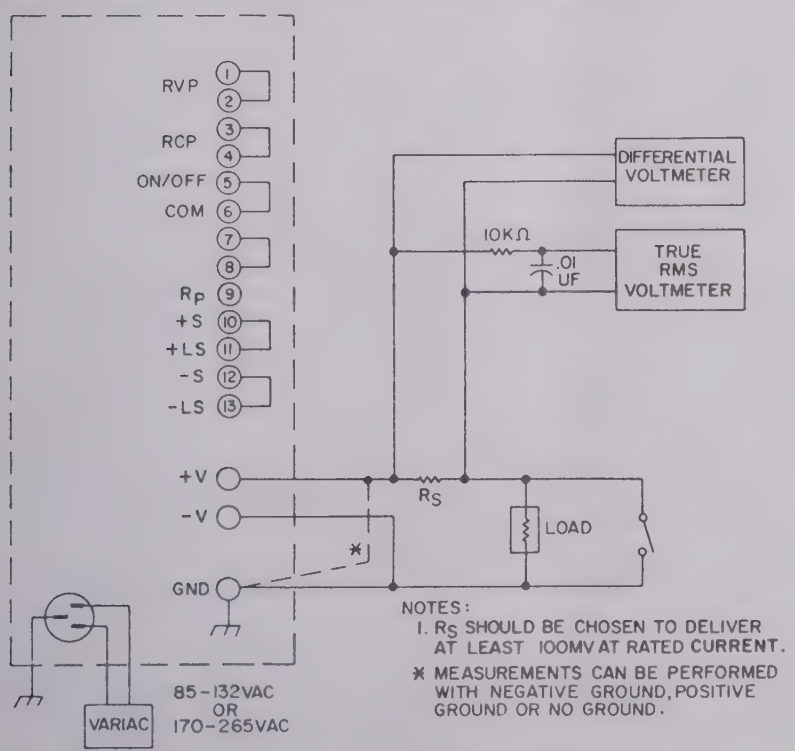



**Figure 13. Test Connections for Constant Current Performance Checks.**

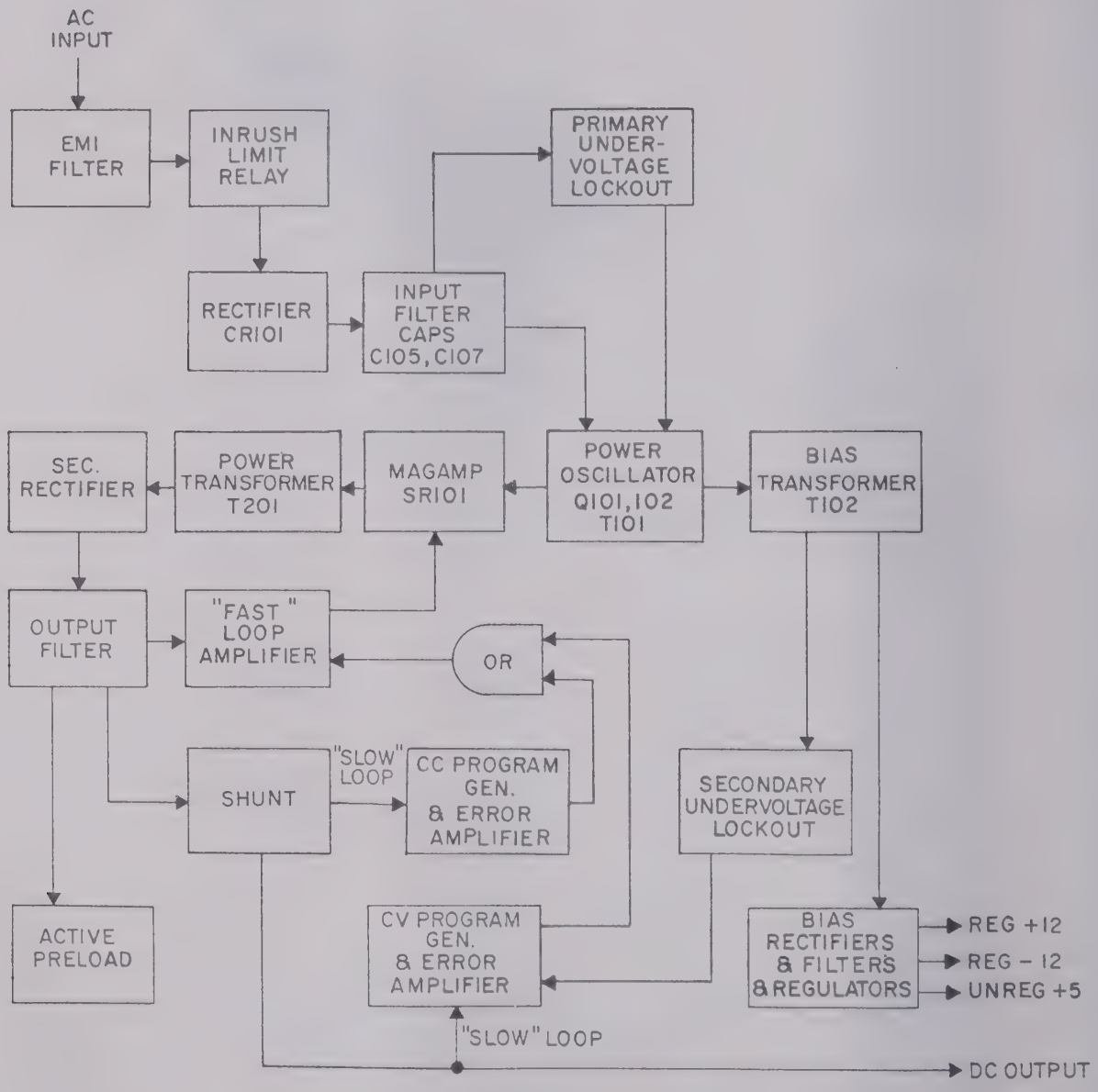
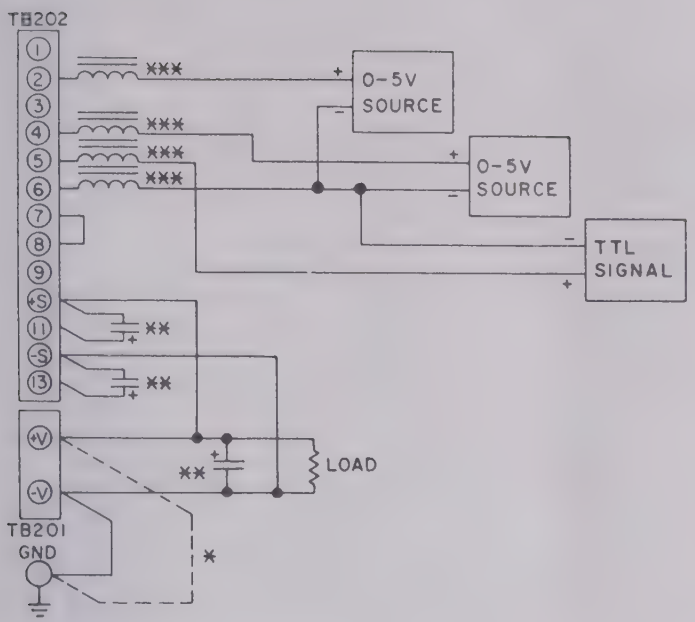
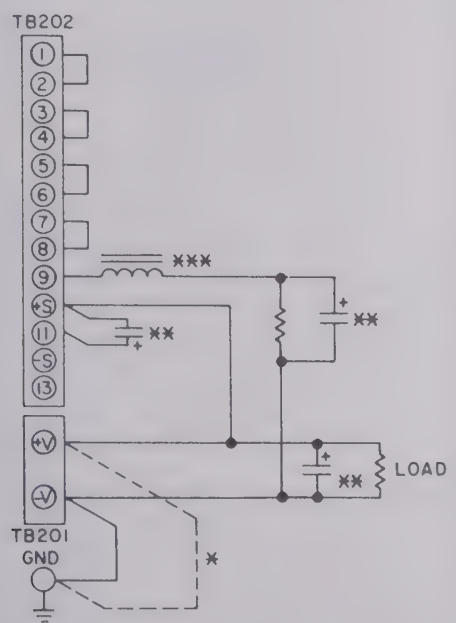



Figure 14. Block Diagram




(A) REMOTE VOLTAGE PROGRAMMING (PIN 2), REMOTE CURRENT PROGRAMMING (PIN 4), REMOTE ON/OFF (PINS 5,6), REMOTE SENSE.



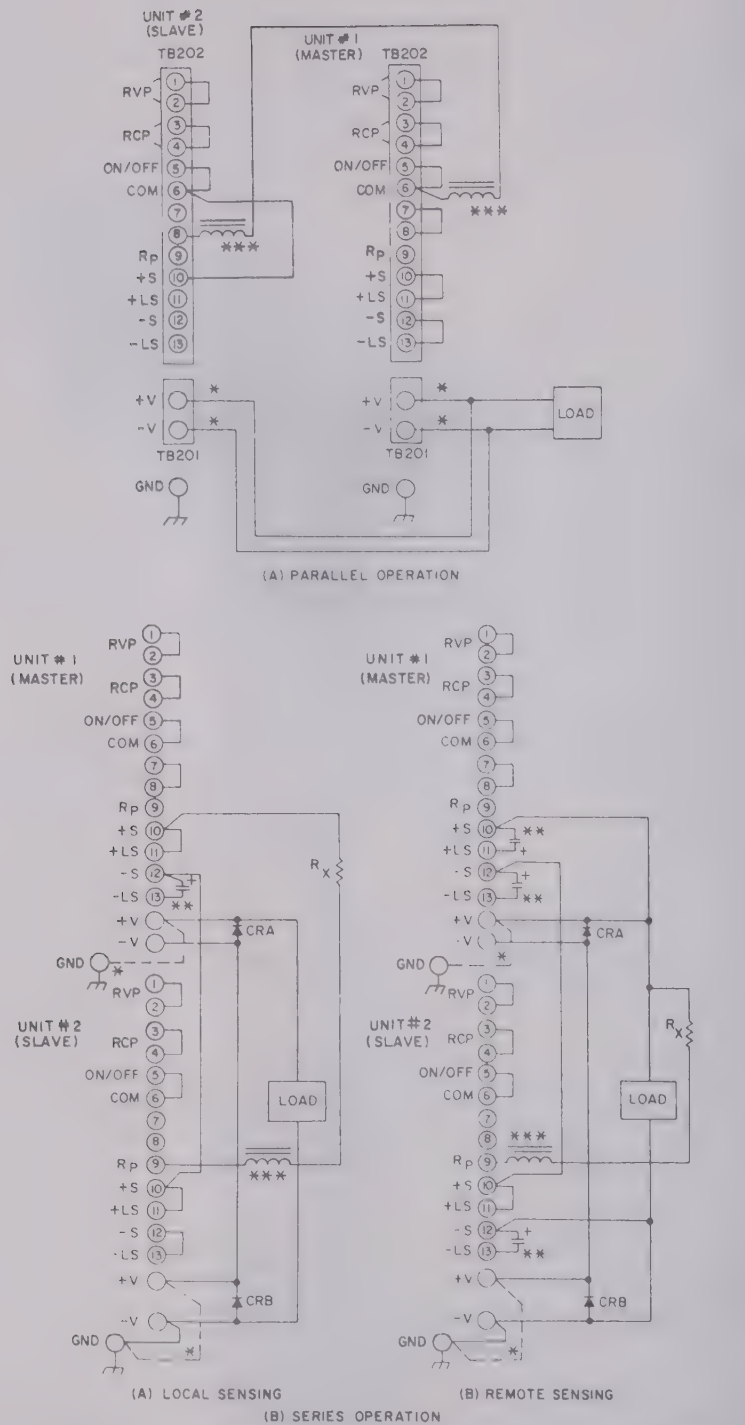

(B) REMOTE RESISTANCE PROGRAMMING (PIN 9), REMOTE SENSE.

NOTE: * FOR POSITIVE GROUND DISCONNECT JUMPER FROM -V TO GND AND RECONNECT FROM +V TO GND.

** A 2.5UF ELECTROLYTIC CAP MAY BE REQUIRED.

*** NOISE SUPPRESSOR IS 8 TURNS ON FAIR RITE PRODUCTS CORP. CORE NO. 5961001103 AND IS CONNECTED WITHIN 3" OF POWER SUPPLY TERMINALS.

Figure 15. Application of Noise Suppressors in Remote Applications Where Extremely Low Noise is Required




NOTE: * MAKE ONLY ONE GROUND CONNECTION FOR SERIES COMBINATION. TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM -V TO GND AND RECONNECT AS DESIRED.

** A 2.5UF ELECTROLYTIC CAP. MAY BE REQUIRED.

*** NOISE SUPPRESSOR IS 8 TURNS ON FAIR RITE PRODUCTS CORP. CORE NO. 5961001103 AND IS CONNECTED WITHIN 3" OF POWER SUPPLY TERMINALS.

**Figure 16. Application of Noise Suppressors in Parallel and Series Operation Where Low Noise is Required.**

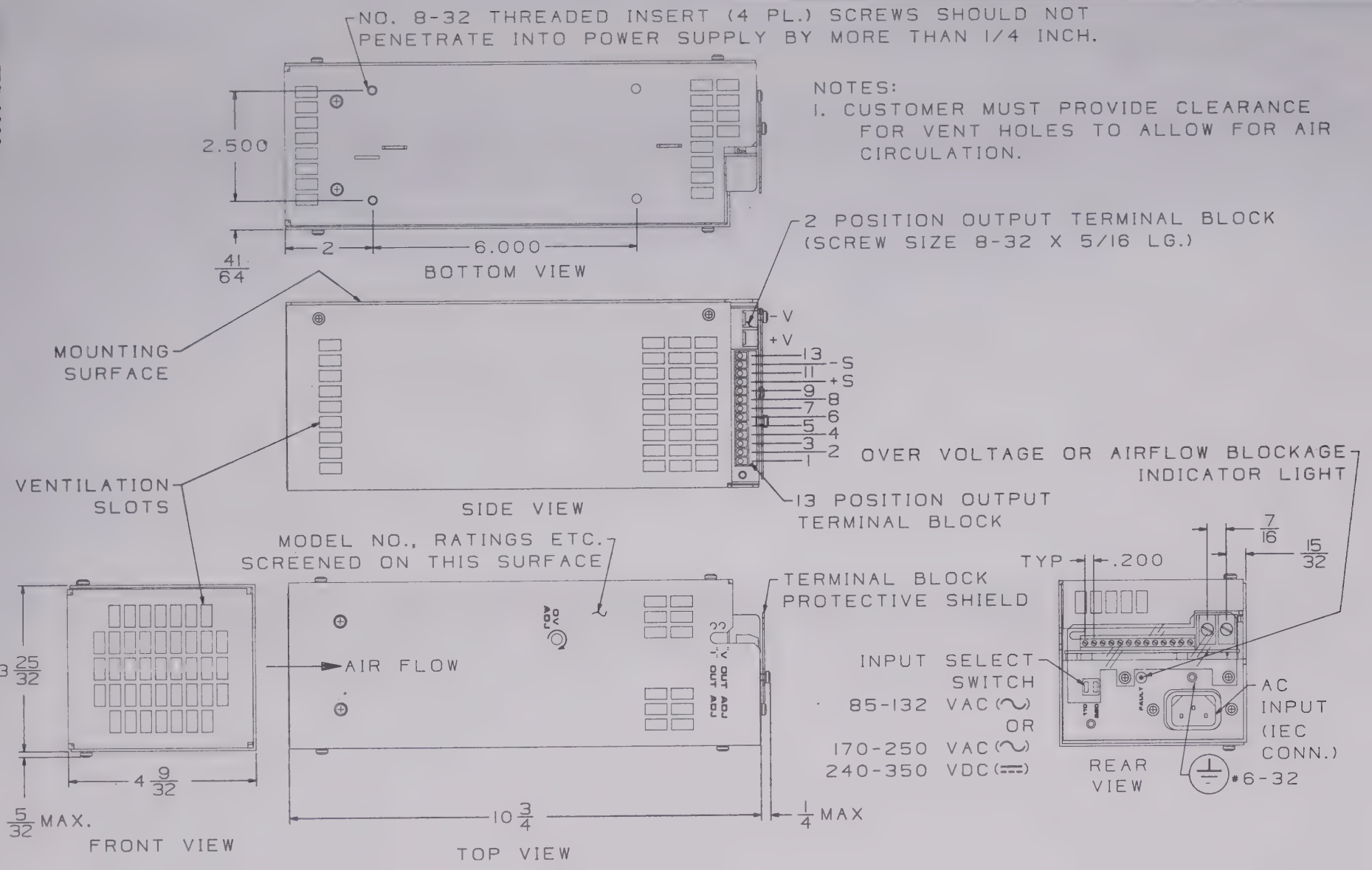
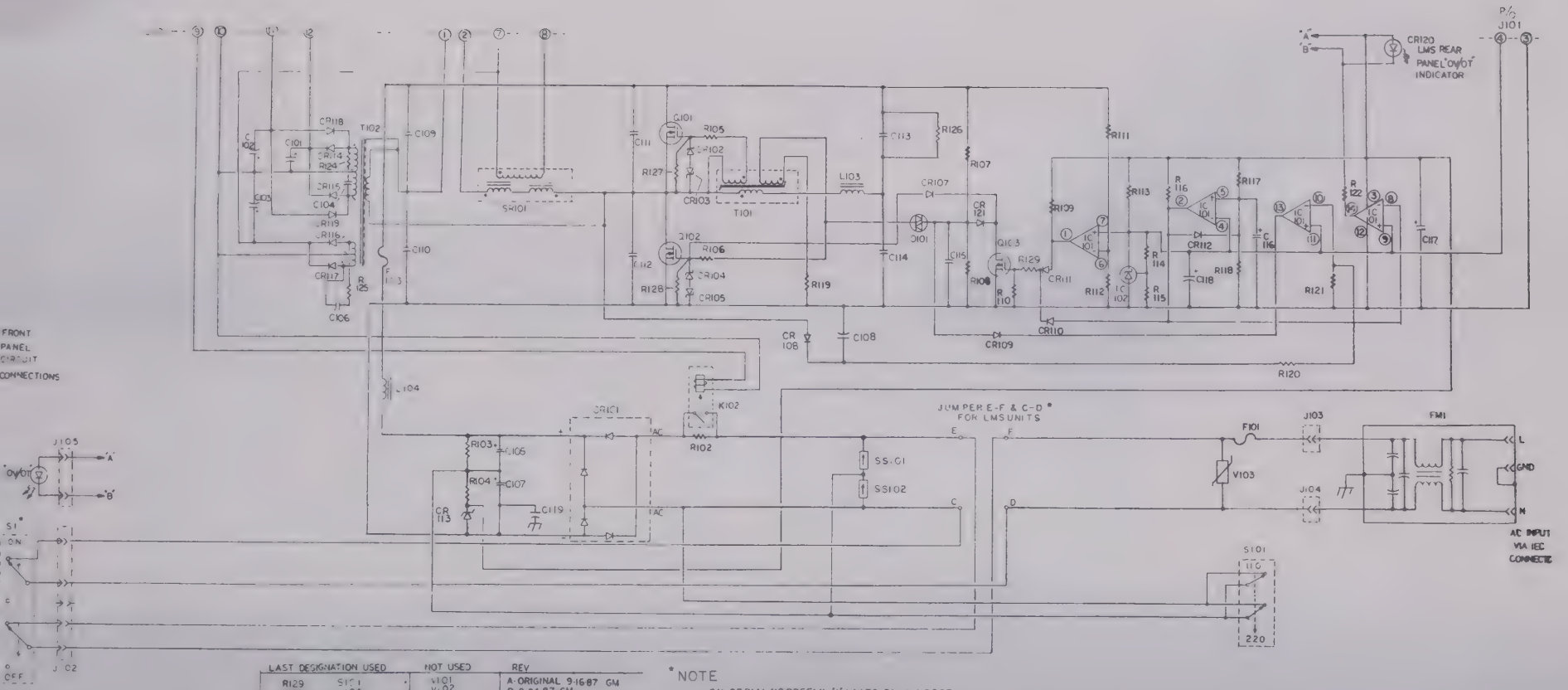



**Figure 17. Outline Drawing**

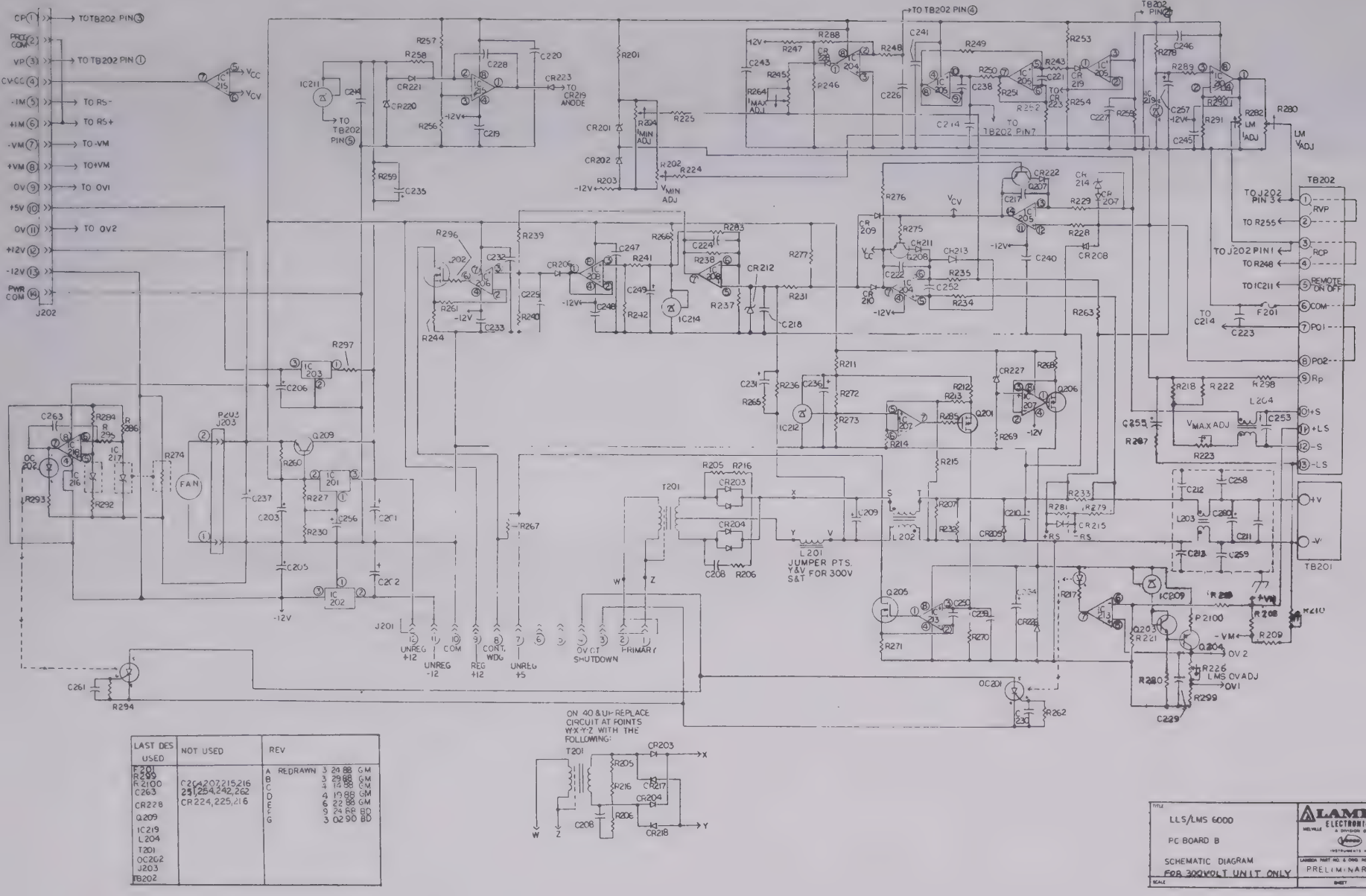



| LAST DESIGNATION USED | | NOT USED | REV |
|---|---|---|---|
| R129 | S1C1 | V101 | A-ORIGINAL 9-16-87 GM |
| C119 | J105 | V102 | B-9-24-87-GM |
| CR121 | S | CR106 | C-10-26-87 BD |
| K102 | SS1C2 | L101 | D-3-4-88 GM |
| L104 | | L102 | E 6-30-88 GM |
| T102 | | F1C2 | F 9-13-88 GM |
| Q103 | | K1C1 | G 3-8-89 BD |
| D101 | | R101 | |
| SR101 | | R123 | |
| IC1C2 | | | |
| V103 | | | |
| F1C3 | | | |

*NOTE

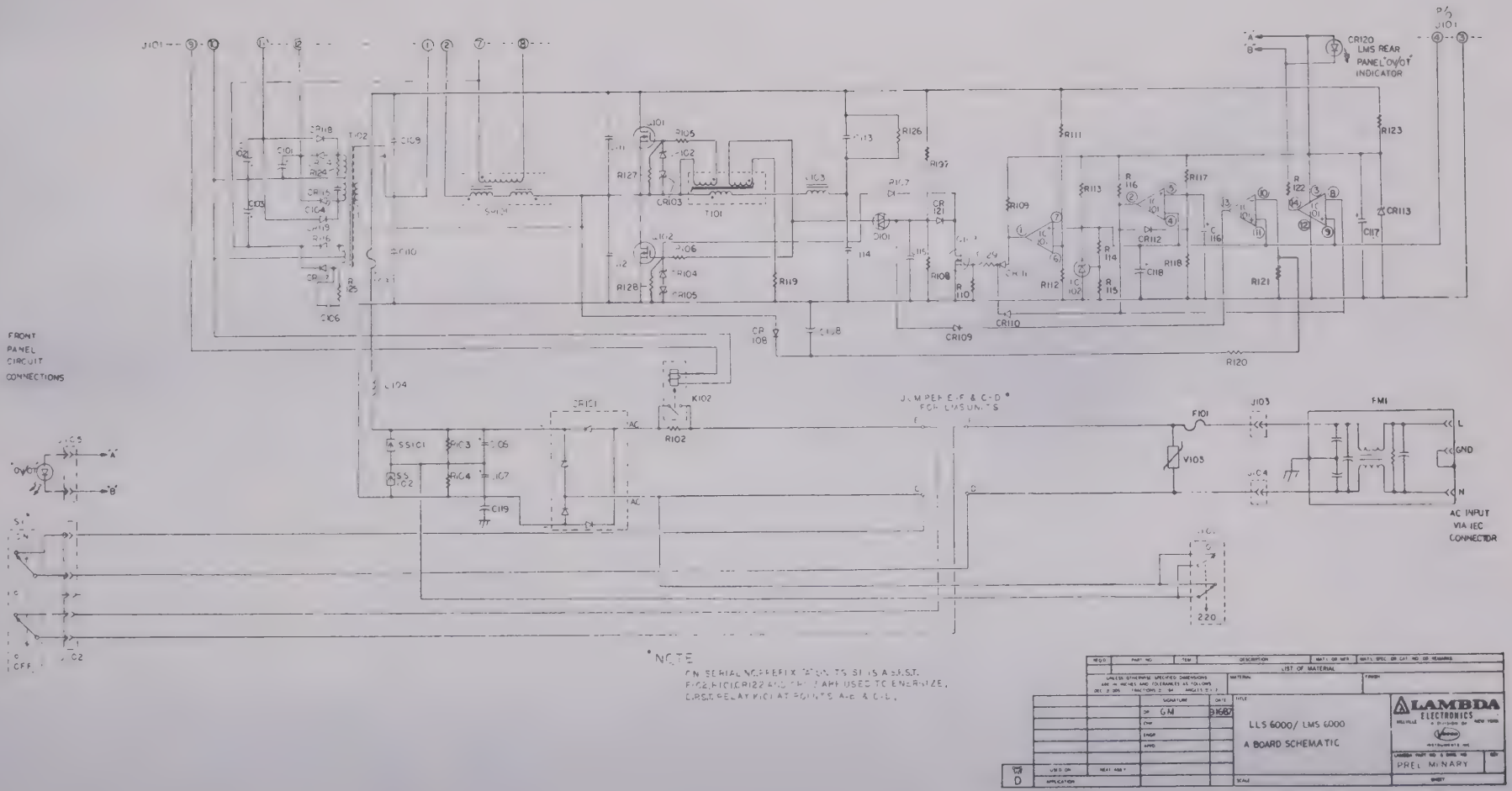
CN SERIAL NO. PREFIX 'A' UNITS S1 IS A S.P.S.T.
F102, R101, CR122 AND CR123 ARE USED TO ENERGIZE D.P.S.T. RELAY K1C1 AT POINTS E-F & C-D.

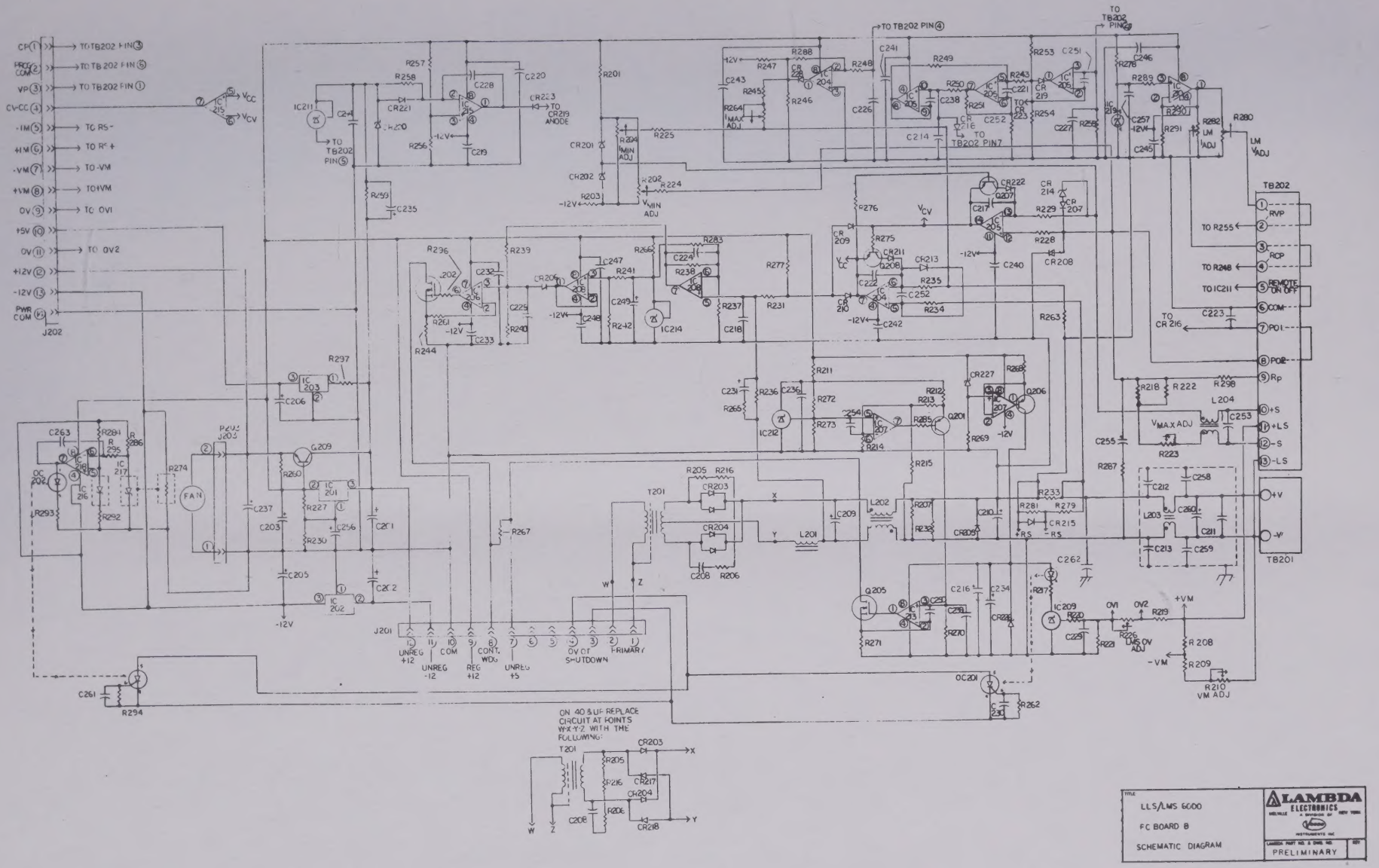
| | |
|---|---|
| LLS 6000/ LMS 6000 | LAMBDA ELECTRONICS |
| A BOARD SCHEMATIC | |
| FOR 300 VOLT UNIT ONLY | PRELIMINARY |



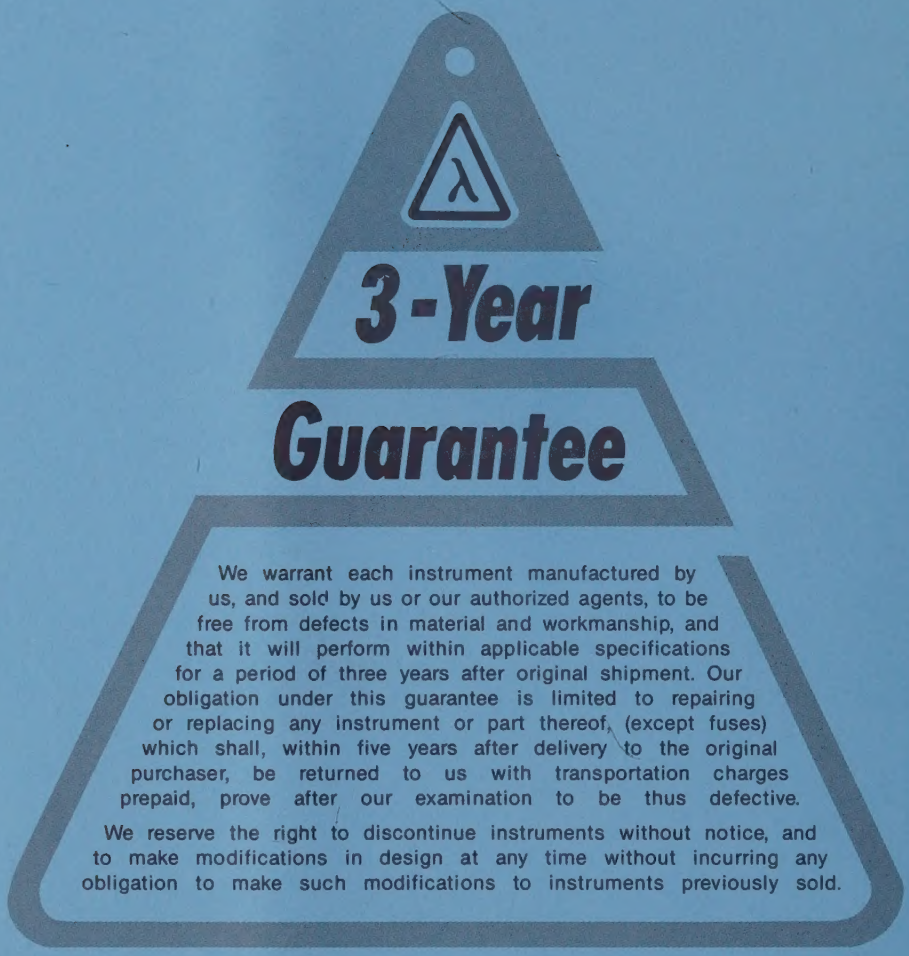

| LAST DES USED | NOT USED | REV | | | |
|---|---|---|---|---|---|
| F201 | | A | REDRAWN | 3 21 88 | GM |
| R299 | | B | | 3 29 88 | GM |
| R2100 | C264,207,215,216 | C | | 4 14 88 | GM |
| C263 | 251,254,242,262 | D | | 4 19 88 | GM |
| CR228 | CR224,225,216 | E | | 6 22 88 | GM |
| Q209 | | F | | 9 24 88 | BD |
| IC219 | | G | | 3 02 90 | BD |
| L204 | | | | | |
| T201 | | | | | |
| OC2G2 | | | | | |
| J203 | | | | | |
| TB202 | | | | | |

| | |
|---|---|
| TITLE | LLS/LMS 6000 |
| | PC BOARD B |
| | SCHEMATIC DIAGRAM |
| | FOR 300VOLT UNIT ONLY |
| LAMBDA ELECTRONICS | MELVILLE, NEW YORK |
| LAMBDA PART NO. & DWG NO. | PRELIMINARY |
| SCALE | SHEET |


FRONT PANEL CIRCUIT CONNECTIONS
CR120 LMS REAR PANEL ON/OFF INDICATOR
JUMPER E-F & C-D FOR LMS UNITS
AC INPUT VIA IEC CONNECTOR
FMI
L
GND
N
220
*NOTE
ON SERIAL NO. PREFIX "E" UNITS SI IS A D.P.S.T. FOR R1C1,CR122 & CR123 ARE USED TO ENERGIZE, D.P.S.T. RELAY. CONTACTS A-E & C-F.
LIST OF MATERIAL
LLS 6000/ LMS 6000
A BOARD SCHEMATIC
LAMBDA ELECTRONICS
PRELIMINARY




| | |
|---|---|
| TITLE | LLS/LMS 6000 |
| | FC BOARD B |
| | SCHEMATIC DIAGRAM |
| LAMBDA PART NO. & DWG. NO. | PRELIMINARY |



# 3-Year Guarantee

We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of three years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.

We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.


**LAMBDA ELECTRONICS INC.**

*Lambda Group of Unitech plc*

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MP MASTER

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